

Cal/Ecotox  
Exposure Factors for Sea Otter (Enhydra lutris)\*

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Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Age at Fledging, Metamorphosis, Weaning	<80 or >120			d	NR	Juvenile	CA	a	1
Age at Sexual Maturity	6.5		6-7	yr	M		CA	b	2
Age at Sexual Maturity	4			yr	F	Juvenile	AK	c	3
Body Weight - Mean	24.3	1.5 SE		kg	B	Adult	Lab	d	4
Body Weight - Mean	18.6			kg	F	Adult	Lab	e	4
Body Weight - Mean	21.1	6.49 SD	14.5-31.7	kg	F	Adult	AK	f	3
Body Weight - Mean			22-25	kg	F	Adult	Monterey; CA	g	5
Body Weight - Mean	29.5	0.3 SE		kg	M	Adult	CA	h	2
Body Weight - Mean	28.3	7.98 SD	21.8-38.6	kg	M	Adult	AK	i	3
Body Weight - Mean			8-25	kg	F	Both Adult and Juv.	Monterey; CA	j	6
Body Weight - Mean			13-34	kg	M	Both Adult and Juv.	Monterey; CA	k	6
Body Weight - Mean	1.96		1.02-2.83	kg	F	Juvenile	AK	l	3
Body Weight - Mean			8.2-24.1	kg	M	Juvenile	CA	m	2
Body Weight - Mean	1.75		1.2-2.5	kg	M	Juvenile	AK	n	3
Clutch or Litter Size	1			pup	F	Adult	AK	o	3
Clutches or Litters per year			14-15	%	B	Adult	AK	p	3
Clutches or Litters per year	Pr (giving birth in a year) = 1- (1-p1)^120(1-p2)^65		0.890 - 0.898		F	Adult	AK	q	7
Clutches or Litters per year	0.9			pups/year	F	Adult	CA	r	1
Dietary Composition	unidentified crab (11.5%), pugettia (8.9%), cancer species (11.0%), unidentified abalone (0.7%), red abalone (1.0%), black abalone (0%), clam (2.9%), turbon snail (12.0%), kelp and holdfasts (0.2%), unidentified (37.7%), mussel (2.6%), annelid (1.0%), limpet (0.2%), scallop (0%), octopus (6.2%), red urchin (0%), cucumaria (0.2%), purple uechin (1.0%), pisaster species (1.7%), barnacle (1.2%)			%	B	Adult	CA	s	8
Dietary Composition	clams (34-61%), mussels (7-20%), crabs (2-11%), other invertebrates (4-5%), unknown prey (12-33%)				NR	Adult	AK	t	9
Dietary Composition	unidentified crab (15.0%), pugettia (4.5%), cancer species (6.8%), unidentified abalone (0%), red abalone (0%), black abalone (0%), clam (0.8%), turbon snail (19.6%), kelp and holdfasts (0%), unidentified (42.9%), mussel (0.8%), annelid (0%), limpet (0%), scallop (0%), octopus (0.8%), red urchin (6.0%), cucumaria (0%), purple urchin (2.3%), pisaster species (0.8%), barnacle (0%)			%	B	Juvenile	CA	u	8

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Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Dietary Composition	abalone (43%), crabs (16%), urchins (13%), other (28%)				B	NR	CA	v	10
Dietary Composition	sea urchins (47.8-70.2%), mussels (0.4-3.1%), sea stars (0.5-0.8%), crabs (1.4-5.2%), clams (0.4-1.8%), octopus (0.0-0.9%), anemone (0.0-0.2%), algal holdfasts (0.0-2.6%), fish (0.0-12.3%), fish eggs (0.0-0.9%), chitons (0.2-0.8%), coralline algae (0.0-0.2%), unknown (14.6-26.7%), unsuccessful (3.4-7.1%)				NR	NR	AK; OR	w	11
Dietary Composition	pismo clams (559), unidentified bivalves (1), rock crabs (1), market crabs (1), unidentified crabs (1), unidentified food items (15)				NR	NR	San Luis Obispo; CA	x	12
Dietary Composition	vertebrates (fish; 50%), mollusks (37%), echinoderms (11%), annelid worms (1%), tunicates (<1%), crabs/shrimp (<1%)				NR	NR	AK	y	3
Duration of Incubation or Gestation	198		119-264	d	F	Adult	Monterey; CA	z	13
Duration of Incubation or Gestation			12-13	mo	F	Adult	AK	aa	3
Duration of Incubation or Gestation			4-6	mo	F	Adult	Monterey; CA	ab	5
Fledging or Weaning Rate	1.0				F	Adult	Monterey; CA	ac	13
Fledging or Weaning Rate	0.75				F	Adult	Monterey; CA	ad	13
Fledging or Weaning Rate	0.4				F	Adult	Monterey; CA	ae	13
Food Ingestion Rate	168			Kcal/kg-d	B	Adult	Lab	af	4
Food Ingestion Rate	234	19 SE		Kcal/kg-d	B	Adult	Lab	ag	4
Food Ingestion Rate	21.6	1.3 SE		% of body mass/d	B	Adult	Lab	ah	4
Food Ingestion Rate	4.04		0.9-7.2	kg/d	F	Adult	Lab	ai	3
Home Range	3.7	3.1 SD		km^2	B	Adult	CA	aj	14
Home Range	5.6	1.9 SD		km^2	B	Adult	CA	ak	14
Home Range	4.7	2.9 SD		km^2	F	Adult	CA	al	14
Home Range	6.8	2.3 SD		km^2	F	Adult	CA	am	14
Home Range	80	19.04 SE	28.2-198.2	ha	F	Adult	Monterey; CA	an	6
Home Range			10 - 1166	ha	F	Adult	CA	ao	15
Home Range	78.0	7.2 SE	55-95	ha	M	Adult	CA	ap	2
Home Range	40.3	4.0 SE	23-65	ha	M	Adult	CA	aq	2
Home Range	0.8	0.8 SD		km^2	M	Adult	CA	ar	14
Home Range	4.6	0.8 SD		km^2	M	Adult	CA	as	14
Home Range	44	13.36 SE	29.3-137.6	ha	M	Adult	Monterey; CA	at	6
Home Range	35	8.75 SE	18.3-57.8	ha	M	Adult	Monterey; CA	au	6
Home Range			7 - 223	ha	M	Adult	CA	av	15
Home Range			32 - 214	ha	F	Juvenile	CA	aw	15
Home Range			221 - 759	ha	M	Juvenile	CA	ax	15
Longevity	11			yr	F	Adult	CA	ay	1

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Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Metabolic Rate	see Figure 1				NR	NR	Lab	az	16
Metabolic Rate	0.99			cc O2/g x hr	NR	NR	Lab	ba	17
Metabolic Rate	1.21			cc O2/g x hr	NR	NR	Lab	bb	17
Metabolic Rate	0.85			cc O2/g x hr	NR	NR	Lab	bc	17
Metabolic Rate	0.72	0.06		cc O2/g x hr	NR	NR	Lab	bd	17
Population Density	15			per 1000 ha	M	Adult	CA	be	2
Population Density	54		43-68	Animals per study area	B	Both Adult and Juv.	Monterey; CA	bf	6
Population Density			3.57 - 19.07	#/km2	B	Both Adult and Juv.	CA	bg	18
Population Density	50			animals per study area	B	NR	CA	bh	10
Population Density	150			animals per study area	B	NR	CA	bi	10
Surface Area	see Figure 3				NR	NR	Lab	bj	16
Survival/ Mortality	review							bk	19
Survival/ Mortality			8-11	%	B	Both Adult and Juv.	AK	bl	3
Survival/ Mortality	0.58				NR	Juvenile	CA	bm	1
Time of Hatching or Parturition	December to February				F	Adult	Monterey; CA	bn	20
Time of Mating/ Laying	review				B	Adult		bo	21
Time of Migration or Dispersal			3.5-8.5	mo	NR	Juvenile	Monterey; CA	bp	5
Water Ingestion Rate	62	27 SE		mL / kg-d	B	Adult	Lab	bq	4
Water Ingestion Rate	269	25 SE		mL/kg-d	B	Adult	Lab	br	4

- Notes**
- a estimate time period that pups spent with mothers; N=24 animals
  - b N=22; Central coast
  - c N=NR; Amchitka Island
  - d combined male and female weights; N=5
  - e N=5
  - f N=254; Amchitka Island
  - g range of body weights; N=2 otters; Mar, Aug; near Monterey
  - h resident and non-resident males were not significantly different; N=22; Central coast
  - i N=79; Amchitka Island
  - j Weight for females; N=9; Monterey, CA
  - k Weight for males; N=15; Monterey, CA
  - l N=6; Age=newborn; Amchitka Island
  - m Individual data available in Table 2; N=33; Central coast
  - n N=4; Age=newborn; Amchitka Island
  - o litter size as indicated by reproductive tract examination; N=278 reproductive tracts; Amchitka Island
  - p annual reproductive rate, based on field count, sex ratio, reproductive tract data; N=NR; Amchitka Island
  - q p1 = daily probability of becoming pregnant during the high probability period  
p2 = daily probability of becoming pregnant during the remaining part of the year.  
p1 and p2 = 0.02 and 0.00067, respectively, based on observations from Prince William Sound, AK.; N=1,482; Age=2-16 years; Spring and fall; Aleutian islands, AK; The 0.890 value appeared to be the best point estimate

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r	annual reproductive rate based on number of pups born during monitoring period; N=13 animals; Condition=breeding
s	dietary composition for adults; N=608; Piedras Blancas
t	relative occurrences of prey items in diet, based on observation (range crosses three locations); N=752-833 foraging dives/site; April-July; Prince William Sound
u	dietary composition for juveniles; N=156; Piedras Blancas
v	The composition is based on occurrence of observed items.; N=15-170; Diablo Canyon nuclear power plant; Point San Luis to Point Buchon
w	percentage (ranges) of total dives that resulted in capture of different prey items at three locations; N=425-584 dives/location; summer, winter; Amchitka and Attu (Aleutian Islands), and Blanco Reef, OR
x	number of prey retrieved, based on observations from shore; N=578 observed retrievals; Pismo Beach
y	mean percent of total stomach content volume contributed by dietary items; N=309 stomachs; Jan, Feb, Oct, Mar, Apr; Amchitka Island
z	N=53; Age=> 3 years; Monterey Bay
aa	estimated gestation including delayed implantation period; N=275 reproductive tracts; Amchitka Island; Includes unimplanted gestation (7-8 mo) and implanted gestation (4.5-5.5 mo)
ab	range of estimated gestation period, based on observations; N=2 otters; near Monterey
ac	pre-weaning survival rate (mothers aged 11-14 years); N=4; Age=11-14 years; Monterey Bay
ad	pre-weaning survival rate (mothers aged 7-10 years); N=12; Age=7-10 years; Monterey Bay
ae	pre-weaning survival rate (mothers aged 3-6 years); N=5; Age=3-6 years; Monterey Bay
af	Net metabolizable energy; N=5
ag	Daily total energy consumption; N=5
ah	N=5
ai	N=1; all mo; Equivalent to 23% of bw per day.
aj	N=11; Condition=Residents; October-December, 1979; Santa Cruz to San Luis Obispo
ak	N=9; Condition=Residents; October-December, 1978; Santa Cruz to San Luis Obispo
al	N=8; Condition=Residents; October-December, 1979; Santa Cruz to San Luis Obispo
am	N=4; Condition=Residents; October-December, 1978; Santa Cruz to San Luis Obispo
an	N=8; July - March; Monterey
ao	daily home range, estimated from hourly triangulations during 24-hr watches using the minimum convex polygon method; N=16 animals; yr-round; Monterey to San Luis Obispo
ap	N=5; winter/spring; Central coast
aq	N=10; summer/fall; Central coast
ar	N=3; Condition=Residents; October-December, 1979; Santa Cruz to San Luis Obispo
as	N=5; Condition=Residents; October-December 1978; Santa Cruz to San Luis Obispo
at	Home range for non-territorial males; N=7; July - March; Monterey
au	Home range for territorial males; N=4; July - March; Monterey
av	daily home range, estimated from hourly triangulations during 24-hr watches using the minimum convex polygon method; N=9 animals; yr-round; Monterey to San Luis Obispo
aw	daily home range, estimated from hourly triangulations during 24-hr watches using the minimum convex polygon method; N=10 animals; yr-round; Monterey to San Luis Obispo
ax	daily home range, estimated from hourly triangulations during 24-hr watches using the minimum convex polygon method; N=5 animals; yr-round; Monterey to San Luis Obispo
ay	oldest animal captured in study; N=1 animal
az	oxygen consumption measured at 15-20 C; N=2; Condition=fed
ba	average metabolic rate in air; N=10; Condition=fasted; See figure for metabolic rate measurements over a range of ambient temperatures.
bb	average metabolic rate in water; N=13; Condition=fasted; See figure for metabolic rate measurements over a range of ambient temperatures.
bc	average basal metabolic rate in water; N=13; Condition=fasted; See figure for metabolic rate measurements over a range of ambient temperatures.
bd	average basal metabolism in air; N=10; Condition=fasted; See figure for metabolic rate measurements over a range of ambient temperatures.
be	maximum density at this time of year; N=7; summer/fall; Central coast
bf	population density, 1975 - 1977; N=54; Monterey, CA; See citation for map of study area with approximate size.
bg	range of densities for entire study area for 2 yrs; N=NR; June - Oct.; Elkhorn Slough
bh	resident population density (see citation for map of study area); N=15-170; Diablo Canyon nuclear power plant; Point San Luis to Point Buchon; Land surveys were done weekly 1973-1978. The population was observed to be predominantly male
bi	population density for resident and non-resident animals (see citation for map of study area); N=15-170; Diablo Canyon nuclear power plant; Point San Luis to Point Buchon
bj	estimated surface area; N=2; Condition=fed
bk	N=NR; all otter species included
bl	annual mortality over two years estimated from carcass searches on beaches; N=1 population (1076 otters); Amchitka Island
bm	pup survival rate to weaning; N=19 animals
bn	peak period of birth; N=NR; Point Lobos State Reserve to Lucia

bo N=NR  
 bp observed ages at which pups were no longer observed with mothers; N=5 pups; near Monterey  
 bq Sea water ingestion rate; N=5  
 br N=5; Nitrogen influx was also measured. Electrolytes were measured using milliequivalents of Mg, Na, Cl, and K. Implications for elimination rates and kidney physiology are discussed.

#### References

- 1 Siniff, Donald B., and Katherine Ralls. 1991. Reproduction, survival and tag loss in California sea otters. *Mar. Mamm. Sci.* 7(3):211-229.
- 2 Jameson, Ronald J. 1989. Movements, home range, and territories of male sea otters off central California. *Mar. Mamm. Sci.* 5(2):159-172.
- 3 Kenyon, Karl W. 1969. The sea otter in the eastern Pacific Ocean. *North Am. Fauna.* (68)1-352.
- 4 Costa, Daniel P. 1982. Energy, nitrogen, and electrolyte flux and sea water drinking in the sea otter *Enhydra lutris*. *Physiol. Zool.* 55(1):35-44.
- 5 Loughlin, Thomas R., Jack A. Ames, and Judson E. Vandever. 1981. Annual reproduction, dependency period, and apparent gestation period in two California sea otters, *Enhydra lutris*. *Fish. Bull.* 79(2):347-349.
- 6 Loughlin, T.R. 1980. Home range and territoriality of sea otters near Monterey, California. *J. Wildl. Manage.* 44(3):.
- 7 Eberhardt, L.L. and K.B. Schneider. 1994. Estimating sea otter reproductive rates. *Mar. Mamm. Sci.* 10(1):31-37.
- 8 Estes, J.A., R.J. Jameson and A.M. Johnson. 1981. Food selection and some foraging tactics of sea otters, In: Chapman, J.A., and D. Pursley, eds. *Worldwide Furbearer Conference Proceedings*; August 3-11, 1980; Frostburg, MD. Frostburg, MD: Worldwide Furbearer Conference, Inc. p 606-641.
- 9 Doroff, Angela M. and James L. Bodkin. 1994. Sea otter foraging behavior and hydrocarbon levels in prey, In: Thomas R. Loughlin, eds. *Marine Mammals and the Exxon Valdez*. San Diego, CA: Academic Press, Inc. p 193-208.
- 10 Benech, S.V. 1979. Sea otter (*Enhydra lutris*) activities within the vicinity of the Diablo Canyon nuclear power plant, 1973-1978. *Cal-Neva Wildl.* 1979:33-44.
- 11 Estes, James A., Ronald J. Jameson, and Elaine B. Rhodes. 1982. Activity and prey selection in the sea otter: Influence of population status on community structure. *Am. Nat.* 120(2):242-258.
- 12 Wendell, Frederick E., Robert A. Hardy, Jack A. Ames and Richard T. Bruce. 1986. Temporal and spatial patterns in sea otter, *Enhydra lutris*, range expansion and in the loss of pismo clam fisheries. *Calif. Fish Game.* 72(4):197-212.
- 13 Riedman, Marianne L., James A. Estes, Michelle M. Staedler, Alisa A. Giles and David R. Carlson. 1994. Breeding patterns and reproductive success of California sea otters. *J. Wildl. Manage.* 58(3):391-399.
- 14 Ribic, Christine A. 1982. Autumn movement and home range of sea otters in California. *J. Wildl. Manage.* 46(3):795-801.
- 15 Ralls, Katherine, Thomas C. Eagle and Donald B. Siniff. 1996. Movement and spatial use patterns of California sea otters. *Can. J. Zool.* 74:1841-1849.
- 16 Iverson, J.A. and J. Krog. 1973. Heat production and body surface area in seals and sea otters. *Norw. J. Zool.* 21(1):51-54.
- 17 Morrison, Peter, Mario Rosenmann and James E. Estes. 1974. Metabolism and thermoregulation in the sea otter. *Physiol. Zool.* 47:218-229.
- 18 Feinholz, Daniela M. 1998. Abundance, distribution, and behavior of the southern sea otter (*Enhydra lutris nereis*) in a California estuary. *Aquat. Mammals.* 24.2:105-116.
- 19 Mason, C.F. 1989. Water pollution and otter distribution: A review. *Lutra.* 32(2):97-131.
- 20 Sandegren, Finn E., Ellen W. Chu and Judson E. Vandever. 1973. Maternal behavior in the California sea otter. *J. Mammal.* 54:668-679.
- 21 Estes, James A. 1980. *Enhydra lutris*. *Mamm. Species.* 133:1-8.

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